TORSIONAL DEFORMITY AFTER INTRAMEDULLARY NAILING OF FEMORAL SHAFT FRACTURES

MEASUREMENT OF ANTEVERSION ANGLES IN 110 PATIENTS

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The torsion of both femora was evaluated in 110 patients who had been treated by intramedullary nailing for unilateral femoral shaft fractures. The anteversion (AV) angle was measured by ultrasound, using a tilted-transducer technique.

True torsional deformity, defined as an AV difference of 15° or more between sides was found in 21 patients, but only eight had complaints related to the deformity. Three patients had reoperations for troublesome external torsional deformities. Of 26 patients with AV differences of 10° to 14°, defined as possible torsional deformity, three had complaints, but none had serious problems. AV differences of up to 29° were observed in symptom-free patients, and no patients with AV differences below 10° had complaints. Static and dynamic nailing showed almost equal tendencies to lead to torsional deformity.

We conclude that torsional deformities are usually established during the operation. Many patients tolerate abnormal torsion, but efforts should be made to reduce and stabilise the femoral shaft fracture with an AV difference of less than 15°.

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During the last decade, locked intramedullary (IM) nailing has become a common method of treatment for femoral shaft fractures in adults. Both fracture reduction and nailing are usually performed as semiclosed procedures, making it impossible to secure an anatomical reduction under direct vision.

Svenningsen, Nesse and Finsen (1986) described more torsional deformity after IM nailing than after plate fixation, but other authors have reported that torsional deformity gave few problems of clinical significance

(Kempf, Grosse and Beck 1985; Johnson and Greenberg 1987; Wiss, Brien and Stetson 1990). Only two studies (Sudmann 1973; Sennerich et al 1992), however, have described torsional deformity assessed by other than clinical methods. A poor correlation between femoral torsion and clinical measurements of hip rotation has been reported (Reikerås and Bjerkreim 1982; Svenningsen et al 1989; Bråten, Terjesen and Rossvoll 1992), and therefore more reliable methods of measuring femoral anteversion (AV) are needed.

Our study aimed to determine the frequency and degree of torsional deformity after IM nailing of femoral shaft fractures, to relate them to clinical complaints and to study the causes.

PATIENTS AND METHODS

Locked IM nailing has been used for femoral fractures at our hospital since 1981. We performed a retrospective study of all patients treated with IM nails for femoral shaft fractures from 1982 to 1991. We excluded patients with bilateral femoral shaft fractures, pathological fractures, previous, simultaneous or later fractures of either femoral neck, and those living outside our district or over 75 years of age at the time of injury.

There was a total of 112 patients and all but two were examined; these failed to attend despite repeated requests. Of the 110 patients reviewed, 31 were women and 79 were men. Their mean age was 29 years (13 to 70) at the time of injury, and 32 years (14 to 72) at the time of review, at least six months after the injury. All the fractures were completely healed.

There were 25 fractures in the proximal third of the femoral shaft, 60 in the middle third, and 25 in the distal third. We assessed comminution according to Winquist, Hansen and Clawson (1984): 35 fractures had no comminution, 24 had type I, 25 type II, 15 type III, and 11 type IV. Twenty-nine patients (26%) had fractures of other bones in their legs.

We used a slotted nail in all cases (Howmedica, Kiel, Germany); 67 (61%) had static locking and 37 (34%) had dynamic locking (Table I). The nail diameter was 12 mm in 30 operations, 13 mm in 23, 14 mm in 38, 15 mm in 10, 16 mm in 3 and was not recorded in 6.

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Almost all the fracture reductions were performed closed, with the patients in a supine position on a traction table. In most cases, traction was by a traction boot with a straight knee. Traction through a distal femoral pin was used in a few cases for distal femoral fractures, or where there were lower-leg fractures or severe knee injuries in the same leg. Distal locking screws were inserted by a 'free-hand' technique (Thoresen et al 1985; Johnson and Greenberg 1987). None of the 67 patients with static locking had later dynamisation.

Table I. Type of locking in 110 patients treated by IM nailing

Type of locking	Patients	
	Number	Per cent
Static, one proximal and two distal screws	67	60.9
Dynamic, one proximal screw	11	10.0
Dynamic, two distal screws	26	23.6
No locking	6	5.5

Evaluation of femoral torsion. Femoral torsion in both legs was determined by ultrasound measurement of the femoral AV angle, using the tilted transducer technique (Terjesen, Anda and Svenningsen 1990). Each patient was examined in a supine position with knees flexed 90° over the edge of the table. The lower legs were strapped in a vertical position allowing us to assume that the posterior tangents of the femoral condyles were horizontal. The anterior tangent of the ultrasound image of the femoral head and greater trochanter was used as a reference line, the transducer being tilted until this line was horizontal on the monitor screen. The angle of tilt of the transducer was then measured from an attached clinometer. We used a correction factor of 10°, subtracting this from the angle measured by ultrasound for reasons explained by Terjesen et al (1990). All ultrasound examinations were performed by the same investigator (MB).

The differences in AV angle on the injured and uninjured sides were classified into three subgroups (Bråten et al 1992):

- 1) < 10°, no significant torsional deformity;
- 2) 10° to 14°, possible torsional deformity; and
- 3) 15° or more, true torsional deformity.

One patient (case 109 in Table II) had already had a reoperation for torsional deformity before this review. His results in Table II were determined from preoperative biplanar radiography (Rippstein 1955).

Complaints. We asked patients for any subjective complaints or observations concerning abnormal rotation of the fractured leg, and also observed their gait with particular attention to torsional deformity.

Statistics. We used chi-squared tests and the Mann-Whitney test for independent samples to assess differ-

ences between groups, using continuity correction for the chi-squared statistics. P values of less than 0.05 were considered to be significant.

RESULTS

Of the 110 patients, 21 had a torsional deformity of 15° or more (Table II); 16 were in external rotation and five in internal rotation. Only eight of these patients had complaints that could be related to their torsional deformity. There were 26 patients with a possible torsional deformity (AV difference 10° to 14°); only three had relatively minor complaints. None of the 63 patients with an AV difference of less than 10° had any problems which could be related to torsional deformity.

The mean AV difference was 22° in patients with complaints and 8° in those without complaints ($p < 0.0001$). Fractures treated by static locking showed a slightly higher incidence of true torsional deformity than fractures with dynamic or no locking (21% as against 16%), but this difference was not statistically significant.

We found no significant relationship between true torsional deformity and age, sex, fracture type, comminution, nail dimension, fracture level or length of follow-up. Patients with additional injuries in their legs had a significantly higher occurrence of true torsional deformity than those with femoral fracture alone ($p = 0.03$).

Thirteen of the 21 patients with torsional deformity of 15° or more had no complaints; the largest AV difference in this group was 29°, and four of these patients had an AV angle of the fractured femur which was outside the normal range of 0° to 30° (Bråten et al 1992; Table II). Of the eight patients with complaints, four had AV angles which were within the normal range. In the group with true torsional deformity, there were no significant differences in the AV angle of the fractured side or the AV difference between those with and without complaints. Patients with complaints had a lower mean age (24 years) than those without complaints (39 years), but the difference was not statistically significant.

DISCUSSION

Torsion of the femur is commonly expressed as the angle of femoral anteversion (AV), which can be measured reliably by biplanar radiography (Dunlap et al 1953; Rippstein 1955) or CT (Weiner et al 1978; Murphy et al 1987; Høiseth, Reikerås and Fønstelein 1989). Terjesen et al (1990) and Bråten et al (1992) have shown that ultrasound using the tilted transducer technique is both reliable and convenient. It is particularly useful for measuring extreme deformities, since biplanar radiography has limited reliability because of positioning problems.

The evaluation of torsional deformities after femoral shaft fractures requires knowledge of normal side-to-side

Table II. Details of 21 patients with true torsional deformity (AV difference 15° or more) after IM nailing of femoral shaft fractures

Case	Age (yr)	Sex	Level*	Type†	Comminution‡	Other injury§	Locking¶	Nail diameter (mm)	Follow-up (mth)	AV difference between sides (deg)	AV angle on fractured side (deg)	Complaints
9	20	M	M	3	III	2	S	15	22	28	-3	Yes
11	17	M	P	1	II	2	S	14	41	-21	36	Yes
13	23	F	M	1	I	0	S	13	21	16	2	Yes
14	19	M	M	1	I	1	S	12	32	26	-7	No
15	17	M	M	1	I	1	S	12	16	-19	22	No
16	15	M	P	1	O	2	S	12	25	24	0	Yes
17	17	F	M	2	I	0	None	12	99	20	-8	No
18	30	M	M	1	II	2	DD	14	18	15	0	Reop
19	28	M	P	2	III	1	S	13	6	40	-25	Reop
20	45	F	M	2	O	0	None	14	54	29	-10	No
22	31	M	M	2	O	0	S	15	49	-18	26	No
45	65	M	D	2	II	2	S	16	15	22	1	No
55	18	M	D	1	I	1	DD	12	80	-15	36	No
60	18	M	D	3	II	0	S	15	62	21	5	Yes
66	40	F	M	4	IV	0	S	14	21	16	0	No
85	57	M	P	3	II	0	DD	15	50	15	5	No
89	59	F	D	3	IV	0	S	12	18	15	10	No
90	61	M	M	2	O	0	S	15	37	15	10	No
107	22	M	P	1	III	0	S	12	20	20	0	No
108	17	M	D	1	O	1	DD	12	24	-20	20	No
109	23	F	P	2	O	0	PD	13	48	42	-12	Reop

* P, proximal; M, middle; D, distal

† 1, transverse; 2, oblique < 45°; 3, oblique > 45°; 4, segmental

‡ according to Winquist et al (1984)

§ 0, none; 1, ipsilateral tibia; 2, other

¶ S, static; PD, proximal dynamic; DD, distal dynamic

Table III. Summary of papers reporting torsional deformities after IM nailing of femoral shaft fractures

Authors	Method of measurement	Number of patients	Deformities
Sudmann (1973)	Biplanar radiography	14	21% > 20°
Kempf et al (1985)	Clinical*	49	None†
Wiss et al (1986)	Clinical	111	7% > 10°
Johnson and Greenberg (1987)	Clinical	179	None > 15°
Alho et al (1991)	Clinical	123	One > 20°
Sennerich et al (1992)	CT	45	40% > 10° 16% > 20°
Bråten et al (1993)	Ultrasound	110	43% > 10° 19% > 15°

* clinical hip rotation

† no definition of torsional deformity

differences in AV angles. Radiographic studies by Brouwer, Molenaar and van Linge (1981) and Reikerås et al (1982) have shown that an AV difference of 10°, and sometimes more, should be considered as a normal variation. Bråten et al (1992) drew a similar conclusion from an ultrasound study of 100 healthy subjects: side differences of up to 13° were detected in symptomless patients. Side differences of up to 15° (Brouwer et al 1981) and 17° (de Jong 1968) have been reported in normal subjects, and we therefore propose that an AV difference of 15° or more after femoral fracture be regarded as a true torsional deformity, and that of 10° to 14° as a possible deformity (Bråten et al 1992). Individual variation in the normal AV angle is common, but the average is 10° to 15° with a range of 0° to 30° (Brouwer et al 1981; Reikerås et al 1982; Bråten et al 1992).

Of the patients examined 47 (43%) had possible or true torsional deformities, and as we expected, no patient with an AV difference less than 10° had any problems that could be ascribed to torsional deformity, while only a few of those with AV differences of 10° to 14° had very minor complaints.

Most reports on the clinical results of locked IM nailing have used only clinical assessment of torsion (Kempf et al 1985; Thoresen et al 1985; Wiss et al 1986; Johnson and Greenberg 1987; Alho, Strømsøe and Ekeland 1991).

AV angles were measured in 14 patients using biplanar radiography by Sudmann (1973). All the patients had unlocked nails, and AV differences of over 20° were revealed in three, only one of whom had any symptoms. Sennerich et al (1992) examined 45 patients by CT and found side differences in torsion of over 10° in 18 patients (40%) and over 20° in seven. They concluded that torsional deformity of less than 20° will not usually be a handicap. Our results confirm this, and both studies show that more torsional deformities are detected by reliable radiographic and ultrasound techniques than by clinical examination (Table III).

Most patients with true torsional deformity accept it, but complaints will of course depend on its magnitude. Side differences exceeding 30° will cause serious problems in most cases, but the converse is not true: one of our patients (case 18) required derotational osteotomy for an AV difference of only 15°. Some of his problems with the external rotated position were probably due to injury to the posterior cruciate ligament and posterolateral capsule of the ipsilateral knee. It is possible, however, that there was a well-compensated AV difference before injury.

We observed AV differences of up to 29° in symptom-free patients. The reason for variation in symptoms caused by torsional differences is obscure, but it seems that young patients, because of their higher physical demands, are most likely to develop symptoms.

In young children it would appear that larger AV differences can be accepted provided that the absolute AV angle of the fractured femur is within normal limits

(Nordbø et al 1992), but we have shown that this is not true for adults: several of our patients with true torsional deformity and complaints had an AV angle which was within normal limits. The ideal result is that a fracture is reduced and stabilised in a manner that takes into account both absolute AV angle and comparison with the contralateral side.

Winkquist et al (1984) considered that torsional deformities were due to both inadequate reduction and the inherent shortcomings of the unlocked nail. Our study and that of Sennerich et al (1992) show that the problem is not eliminated by the use of locking nails. We found an equal tendency to torsional deformity after static and dynamic locking, indicating that the error was established during the operation.

Kempf et al (1985) used traction with a femoral condylar pin, allowing the lower leg to hang vertically, while most of our cases had boot traction through a straight knee. Distal femoral traction gives better torsional control, but does not solve the problem: several of our patients with ipsilateral tibial injury had pin traction and still developed true torsional deformities (Table II).

Winkquist et al (1984) reported that external malrotation was more common after proximal shaft fractures treated by unlocked nailing, probably because of the pull of the iliopsoas on the proximal fragment. We could not confirm this: deformities were independent of fracture level. We had anticipated that distal fractures would show more malrotation due to twisting of the distal femoral fragment for the insertion of distal locking screws by a free-hand method, but we failed to detect any such tendency.

Conclusions. Torsional deformities of 10° to 14° are unlikely to cause significant problems, deformities of over 15° will often cause problems, and those over 30° are likely to produce serious complaints. Most torsional deformities seem to be established during operation, and efforts should be made to avoid this.

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